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(71) Applicant: **COOPER INDUSTRIES INC.**
1001 Fannin Street, Suite 4000
Houston Texas 77002(US)

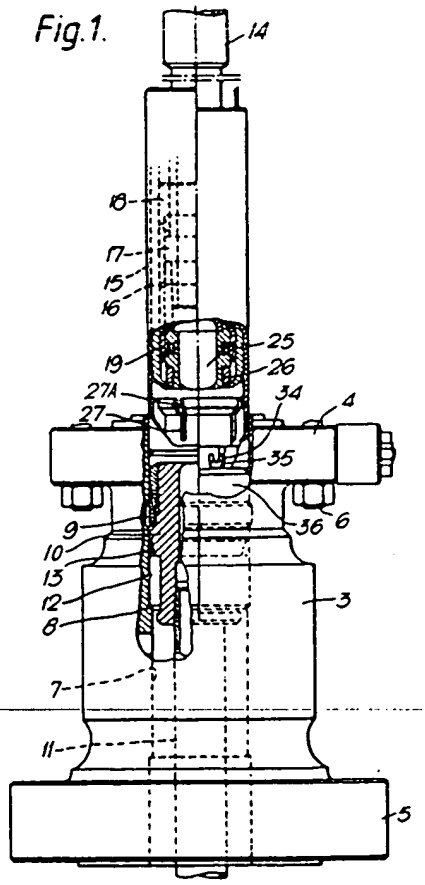
(72) Inventor: **Thornburrow, Edward Thomas**
116 Potternewton Lane
Leeds, West Yorkshire LS7 3DR(GB)
Inventor: **Frazer, Neil Francis**
Parkhill Cottage, Cow Lane, South Woodchester
Stroud, Gloucestershire GL5 5HN(GB)

(74) Representative: **Jackson, Peter Arthur et al**
GILL JENNINGS & EVERY, Broadgate House, 7 Eldon Street
London EC2M 7LH (GB)

(54) Tubing suspension equipment for a wellhead.

(57) A tool for running in and securing a tubing string includes three concentric mutually rotatable sleeves (15,16,17,18,19). The inner sleeve is formed in upper and lower telescopic parts (17,18,19). When these parts are extended rotation can be transmitted from a landing string (14) via both inner sleeve parts for connection to the hanger. When the two inner sleeve parts are retracted there is no direct drive between the parts but rotation of the upper inner sleeve part by the landing string is transmitted via a sun gear on the upper inner sleeve part, planetary gears on the central sleeve (16), and a ring gear (33) on the outer sleeve (15), for rotating a locking ring (36) to expand a split ring (39) to secure the hanger (10) to a spool (3).

Fig.1.



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During completion of a wellhead in an oil or gas field, the tubing string, suspended from a landing string is run in down through the casing assembly, which has previously been cemented in the bore. The tubing string is run in until the tubing hanger at the upper end of the tubing string lands in a tubing spool, which is stacked at the wellhead on casing spools. The tubing hanger is then conventionally locked down to the tubing spool by a ring of tie down screws, which are screwed radially in through the wall of the tubing spool until the tips of the screws engage in an annular groove in the tubing hanger. Although the screws are sealed with glands where they pass through the wall of the tubing spool, they inevitably penetrate the sealed envelope containing the well pressure and are a source of potential failure. A recent development to overcome this problem has been to use a hanger which is secured within its spool by screwing or other manipulation of a locking ring around the hanger body to set locking means between the hanger and spool. This requires the use of a rotary tool.

Another safety factor frequently required in modern well technology is the provision of a control line from a source of hydraulic pressure external of the wellhead down to a subsurface safety valve within the tubing some distance below the surface. The valve is held open by hydraulic pressure applied through the control line but in the event of a catastrophe causing pressure loss in the control line, the valve is automatically closed to isolate the tubing below the valve. Conventionally such control line is a flexible metal pipe of nominal quarter inch external diameter, which is strapped to the outside of the tubing and lowered and raised with the tubing string. In order to pass to the outside of the wellhead without interrupting the annular seal at the top of the annulus between the tubing and inner casing, the control line has been coupled at its upper end to the lower end of an axial bore extending up through the wall of the tubing hanger, and hence through a radial branch to a passageway in the hanger spool via an interface seal between two annular sealing rings interposed between the spool and hanger. The coupling between the upper end of the tubing and the bore in the tubing hanger is a further potential source of failure such that if it became inadvertently disconnected, the pressure loss in the control line would unnecessarily close the subsurface safety valve and involve an unnecessary and costly interruption in the operation of the well. For this reason there has been the further requirement that the control line be a continuous tube which passes through a bore extending from axial end to end through the wall of the tubing hanger. However, during running in of the tubing string, the extra length of control line tubing above the hanger has had to be coiled helically in the of the hanger or accommodated alongside the landing string. In either case the tubing interferes with the application of the rotary tool to set the hanger locking means and two tools have had to be used in turn, one to run in the tubing string and the other to set the locking means.

The object of the present invention is to enable the suspension of a tubing string with a continuous control line upon completion of a wellhead using a hanger which is secured in the spool by locking means set by rotation of a locking ring on the hanger body and a single tool both for running in and for rotating the locking ring.

In accordance with the invention, this object is achieved by providing a tubing spool which is arranged to be stacked in conventional manner in a wellhead, and a tubing hanger which is arranged to be suspended in the spool, for example by means of a conventional tapered landing shoulder. The hanger body is provided with a passageway extending from axial end to end through the wall thereof for accommodating a continuous control line for a subsurface safety valve. Locking means, such as lugs or a split ring located in a locking groove in the hanger, for locking the hanger to the spool, are set by a locking ring which is rotatable around the hanger body, particularly screwed down on the hanger body. The tubing string is run in and the locking means is set by means of a special running tool which suspends the hanger and tubing string from the conventional landing string. The running tool comprises radially inner, radially central and radially outer, mutually rotatable, coaxial sleeves. The radially outer sleeve is provided with an inner ring gear and at its lower end is releasably connectable, for example by means of at least one pin and J-slot, to the hanger locking ring for transmission of torque to the locking ring. The radially central sleeve is provided with a ring of planetary pinions in mesh with the ring gear, with a passageway extending from axial end to end through the wall of the radially central sleeve for accommodating the continuous control line for the subsurface safety valve, and, at its lower end is releasable keyable to the hanger body to prevent mutual rotation about the tubing axis. The radially inner sleeve is formed in mutually sealed, upper and lower telescopic parts, the lower part being releasably connected at its lower end to the hanger body for supporting the tubing string, and the upper part being arranged to be secured, in use, to the landing string, the upper and lower parts having means, such as inter-engaging dogs, for transmitting rotation therebetween when they are telescopically extended but not when they are telescopically retracted, and the upper part having an external sun

gear which meshes with the planetary pinions when the upper and lower parts are telescopically retracted but not when they are telescopically extended.

In use, the running tool, suspended from the landing string, is lowered on to the hanger, and the lower end of the central sleeve of the tool is keyed to the hanger body. At this time the landing string has not been over lowered, so that the weight of the tool maintains the telescopic inner sleeve parts of the tool extended and there is direct rotational drive between the parts. The landing string is then rotated to secure the lower part of the inner sleeve of the tool to the hanger body, most conveniently by screwing the lower end of the lower part of the inner sleeve to the usual landing thread at the upper end of the hanger body. The outer sleeve of the tool is then manipulated by hand to engage the outer sleeve of the tool with the hanger locking ring. If one or more pin and J-slots are utilised, the or each pin will be manipulated into the closed end of the respective J-slot.

The tubing string is then run in until the hanger lands in the spool. The landing string is lowered slightly to cause retraction of the inner sleeve parts of the running tool so that the sun gear comes into engagement with the pinions. The running tool is thus in a configuration to act as a planetary gear. Rotation of the landing string will then cause rotation of the upper inner sleeve part and, via the pinions, the outer sleeve of the running tool so that the locking ring of the hanger is rotated to set the locking means. At this time no rotation is transmitted to the lower inner sleeve part. Thereafter the landing string is raised to tension the running tool and extend the upper and lower inner sleeve parts so that the sun gear moves axially out of engagement with the pinions and the dogs or other means re-engage. Rotation of the landing string is then transmitted not to the outer sleeve but to the lower inner sleeve part to disconnect this from the hanger body. Provided that the releasable connection between the lower end of the outer sleeve and the hanger locking ring is now releasable by axial movement, for example as a result of the pin or pins being in the bottom of the open lengths of the respective J-slot, the landing string and running tool can be withdrawn out of engagement with the hanger. If the landing string always rotates in the same direction both to pick up the hanger and to engage the locking means, as is conventional, if the connection between the lower inner sleeve part and the hanger body is a screw threaded connection, and if the hanger locking ring is screwed down the hanger body to set the locking means, the two screw threads will need to be of different hand since the planetary pinions will reverse the direction of drive from the upper inner sleeve part to the outer sleeve. After separation from the hanger, the running tool can be drawn upwardly with the landing string, the radially central sleeve of the running tool stripping up over the continuous control line.

The running tool with its three sleeves, with means at the lower end of its radially outer sleeve for releasable connection to a hanger locking ring for transmission to the locking ring of rotation about the tubing axis, with means at the lower end of its central sleeve for releasably keying the radially central sleeve to the hanger to prevent mutual rotation about the tubing axis, and with means at the lower end of the lower part of its inner sleeve for releasable connection to the hanger for supporting the tubing string, forms an independent aspect of the invention.

A spool and hanger assembly for use in suspending a tubing string upon completion of a wellhead, the assembly comprising a tubing spool having a bore, a tubing hanger which is arranged to be received in the bore, the hanger being provided with a passageway extending from axial end to end through the wall thereof for accommodating a continuous control line for a subsurface safety valve, locking means for locking the hanger to the spool; a locking ring which is rotatable around a body of the hanger for setting the locking means; the hanger body being provided with means for releasable connection to a running tool for supporting, in use, the tubing string, and with means for releasable keying to a part of the tool to prevent mutual rotation therebetween; and the hanger locking ring being provided with means for releasable connection to a part of the tool for transmission of torque to rotate the locking ring also forms a further independent aspect of the invention.

An example of equipment constructed in accordance with the present invention, is illustrated in the accompanying drawings, in which:

Figure 1 is an elevation, with parts broken away in section, of tubing suspension equipment constructed in accordance with the present invention; and,

Figure 2 is an axial section through part of Figure 1 to an elarged scale.

The illustrated equipment includes a tubing spool 3, which is arranged to be stacked on casing spools and connected to adjacent spools and conventional valving by means of flanges 4 and 5 and stud bolts 6. The inner bore 7 of the spool is provided with an annular tapered landing shoulder 8 and an annular locking groove 9.

The spool is arranged to suspend a tubing string consisting of a tubing hanger 10 and tubing 11. When the hanger is landed in the spool, the landing shoulder 8 is engaged by a ring 12, which is slidable up the hanger body under the string weight to energise a seal 13 into sealing engage-

ment between the spool and hanger.

The tubing string is arranged to be run in and secured by means of a running tool which is suspended from a landing string 14 and which is shown more clearly in Figure 2. The tool consists of three mutually rotatable and axially slidable sleeves consisting of a radially outer sleeve 15, a radially central sleeve 16, and a radially inner sleeve formed by an upper part 17 and a lower part formed of sub parts 18 and 19 which are securely fixed together by a screw thread 20 and pins 21. The upper and lower inner sleeve parts 17;18,19, are telescopically slidable relatively to one another between an extended position shown on the left-hand side of Figure 2, and retracted position shown on the right-hand side of Figure 2. A ring of vent holes 18A assists movement upon change in volume in the closed annular space between the inner sleeve parts. The two parts are guided relatively to one another by means of bearing rings 22 and are sealed relatively to one another by means of an annular sealing ring 23. In their extended position, dogs 24 on the two inner sleeve parts engage one another so that torque is transmitted from one part to the other. When the parts are retracted, the dogs 24 are separated so that torque cannot be transmitted between the parts.

At its lower end the lower inner sleeve part has a nose 25 which is externally screw threaded and arranged to screw into a landing thread 26 in the upper part of the hanger 10. The screw threads could be inverted so that that on the lower inner sleeve part is an internal thread.

The central sleeve part 16 of the tool is provided at its lower end with downwardly projecting fingers 27 which engage in complementary axial keyways 27A in the side wall of the body of the hanger 10 to prevent relative rotation between that sleeve and the hanger. The central sleeve 16 is also provided with a ring of planetary pinions 28, each of which projects both outwardly and inwardly of the sleeve wall. In the extended position of the inner sleeve parts as shown on the left-hand side in Figure 2, the pinions are clear of a sun gear 29 which is fixed on the upper inner sleeve part 17, but engage the sun gear when the inner sleeve parts are retracted as shown on the right-hand side of the Figures. The central sleeve 16 is also provided with a passageway 30 extending from end to end in its wall to accommodate a continuous control line 31, which also passes up through a similar passageway 32 extending from end to end through the wall of the hanger 10. The outer sleeve 15 of the tool is provided on its inner surface with a ring gear 33 which is continually in mesh with the pinions 28, and at its lower end with a pair of diametrically opposed inwardly projecting pins 34. These pins engage in J-slots 35 formed in a locking ring 36 which is screwed by means of interengaging screw threads 37 on to the outside of the hanger 10. The ring 36 has a tapered nose 38, which, upon screwing down of the ring, wedges behind a split ring 39, located in an annular locking groove 40 in the wall of the hanger, to expand the ring partly into the locking groove 9.

As previously explained, the tubing string 11 is run in and secured, supported in slips, and the tubing hanger 10 attached. First the tool is lowered and the fingers 27 are introduced into their complementary keyways 27A in the hanger 10. At this time the screw threads on the nose 25 are stood off from those in the socket 26. The landing string is then lowered slightly but without releasing tension in the tool, and is rotated, for example, clockwise to engage the nose 25 in the socket 26. The outer sleeve 15 of the tool is then manipulated by hand so that the pins 34 enter the J-slots 35 and are moved to the closed ends of the slots. The tubing string is then unslipped and owered fully into the spool, until the hanger makes a landing. The landing string is lowered further to retract the inner sleeve parts of the tool, thereby disengaging the dogs 24, and bringing the sun gear 29 into mesh with the pinions 28. The locking string is then rotated in the same clockwise direction so that the pins 34 move across the bottoms of the J-slots and then rotate the locking ring 36 so that this is screwed down to expand the ring 39 and lock the hanger in the spool. The screw thread 37 is of a different hand to that between the nose 25 and socket 26. Thereafter the landing string is raised slightly to extend the inner sleeve parts of the tools thereby reengaging the dogs 24 and disconnecting the sun gear 29 from the pinions 28. Anticlockwise rotation of the landing string now causes the nose 25 to be screwed out of the socket 26. the threads between which being breakout threads which preferentially unscrew. When the nose 25 is clear of the socket 26, the tool can be lifted away from the hanger, by raising the landing string 14, the fingers 27 lifting out of the complementary keyways and the pins 34, which are now in the open parts of the J-slots, lifting out of the slots. As the tool is lifted by tension applied to the upper inner sleeve part 17, the central sleeve 16 is picked up at a shoulder 29A by the top of the sun gear 29, and the outer sleeve 15 is picked up at a shoulder 15A by the top of the central sleeve 16.

Claims

1. A running tool which is arranged to be connected between a landing string (14) and a tubing hanger (10) for use in securing a tubing string upon completion of a wellhead; the run-

ning tool comprising radially inner (17,18,19), radially central (16) and radially outer (15), mutually rotatable, coaxial sleeves; the radially outer sleeve (15) being provided with an inner ring gear (33), and, at its lower end, with means (34) for releasable connection to a locking ring (36) which is rotatable on a hanger body (10) for transmission to the locking ring (36) of torque about the tubing axis; the radially central sleeve (16) being provided with a ring of planetary pinions (28) in mesh with the ring gear (33) with a passageway (30) extending from axial end to end through the wall thereof for accommodating a continuous control line (31) for a sub-surface safety valve, and, at its lower end, with means (27) for releasably keying the radially central sleeve (16) to the hanger body (10) to prevent mutual rotation about the tubing axis; and the radially inner sleeve (17,18,19) being formed in mutually sealed, upper and lower telescopic parts (17;18,19), the lower part having at its lower end means (25) for releasable connection to the hanger body (10) for supporting the tubing string, and the upper part being arranged to be secured, in use, to the landing string (14), the upper and lower parts (17;18,19) having means (24) for transmitting torque therebetween when they are telescopically extended but not when they are telescopically retracted, and the upper part having an external sun gear (29) which meshes with the planetary pinions (28) when the upper and lower parts are telescopically retracted but not when they are telescopically extended.

2. A running tool according to claim 1, wherein the means (24) for transmitting torque between the upper and lower parts (17;18,19) of the radially inner sleeve when they are mutually extended are inter-engaging dogs (24).

3. Equipment for use in suspending a tubing string upon completion of a wellhead, the equipment comprising a tubing spool (3) which is arranged to be stacked in a wellhead; a tubing hanger (10) which is arranged to be suspended in the spool (3) and a body of which is provided with a passageway (32) extending from axial end to end through the wall thereof for accommodating a continuous control line (31) for a subsurface safety valve; locking means (39) for locking the hanger (10) to the spool (3); a locking ring (36) which is rotatable around a body of the hanger body (10) for setting the locking means (39); and a running tool which is arranged to be connected between a landing string (14) and the tubing hanger body (10) for running in the tubing string and securing the tubing hanger (10) in the tubing spool (3), the running tool comprising radially inner (17,18,19), radially central (16) and radially outer (15), mutually rotatable coaxial sleeves, the radially outer sleeve (15) being provided with an inner ring gear (33), and, at its lower end being releasably connectible to the hanger locking ring (36) for transmission of torque to the locking ring (36), the radially central sleeve (16) being provided with a ring of planetary pinions (28) in mesh with the ring gear (33), with a passageway (30) extending from axial end to end through the wall of the radially central sleeve (16) for accommodating the continuous control line (31) for the subsurface safety valve, and, at its lower end being releasably keyable to the hanger body (10) to prevent mutual rotation about the tubing axis, and the radially inner sleeve (17,18,19) being formed in mutually sealed, upper and lower telescopic parts (17;18,19), the lower part being releasably connectible at its lower end to the hanger body (10) for supporting the tubing string, and the upper part being arranged to be secured, in use, to the landing string (14), the upper and lower parts (17;18,19) having means (24) for transmitting torque therebetween when they are telescopically extended but not when they are telescopically retracted, and the upper part having an external sun gear (29) which meshes with the planetary pinions (28) when the upper and lower parts (17;18,19) are telescopically retracted but not when they are telescopically extended.

4. Equipment according to claim 3, wherein the means (24) for transmitting torque between the upper and lower parts (17;18,19) of the radially inner sleeve of the running tool, when such parts are mutually extended, are inter-engaging dogs (24).

5. Equipment according to claim 3 or claim 4, wherein the locking means (39) is displaceable radially outwardly into engagement with a locking groove (9) in the spool by the wedging action of the locking ring (36) which is screwed on the hanger body (10).

6. Equipment according to claim 5, wherein the locking means (39) is a split ring located in a locking groove (40) in the hanger body (10).

7. Equipment according to claim 5 or claim 6, wherein the locking ring (36) is screwed down the hanger body (10) to set the locking means

(39) and the releasable connection between the lower end (25) of the lower inner sleeve part (19) of the running tool and the tubing hanger (10) is a screw thread (26) of opposite hand to that of the locking ring (36).

8. Equipment according to any one of claims 3 to 7, wherein the releasable connection between the lower end of the radially outer sleeve (15) of the running tool and the hanger locking ring comprises at least one pin (34) and J-slot (35).

9. A spool and hanger assembly for use in suspending a tubing string upon completion of a wellhead, the assembly comprising a tubing spool (3) having a bore (7), a tubing hanger (10) which is arranged to be received in the bore (7), a body of the hanger (10) being provided with a passageway (32) extending from axial end to end through the wall thereof for accommodating a continuous control line (31) for a subsurface safety valve, locking means (39) for locking the hanger (10) to the spool (3); a locking ring (36) which is rotatable around the hanger body (10) for setting the locking means (39); the hanger body (10) being provided with means (26) for releasable connection to a running tool for supporting, in use, the tubing string, and with means (27,27A) for releasable keying to a part of the tool to prevent mutual rotation therebetween; and the hanger locking ring (36) being provided with means (35) for releasable connection to a part (34) of the tool for transmission of torque to rotate the locking ring (36).

10. An assembly according to claim 9, wherein the locking means (39) is displaceable radially outwardly into engagement with a locking groove (9) in the spool (3) by the wedging action of the locking ring (36) which is screwed on the hanger body (10).

11. Equipment according to claim 10, wherein the locking means (39) is a split ring located in a locking groove (40) in the hanger (10).

12. Equipment according to claim 10 or claim 11, wherein the locking ring (36) is screwed down the hanger body (10) to set the locking means; and the means for releasably connecting the hanger body (10), in use, to the running tool, is a screw thread (26) of opposite hand to that of the locking ring (36).

Fig.1.

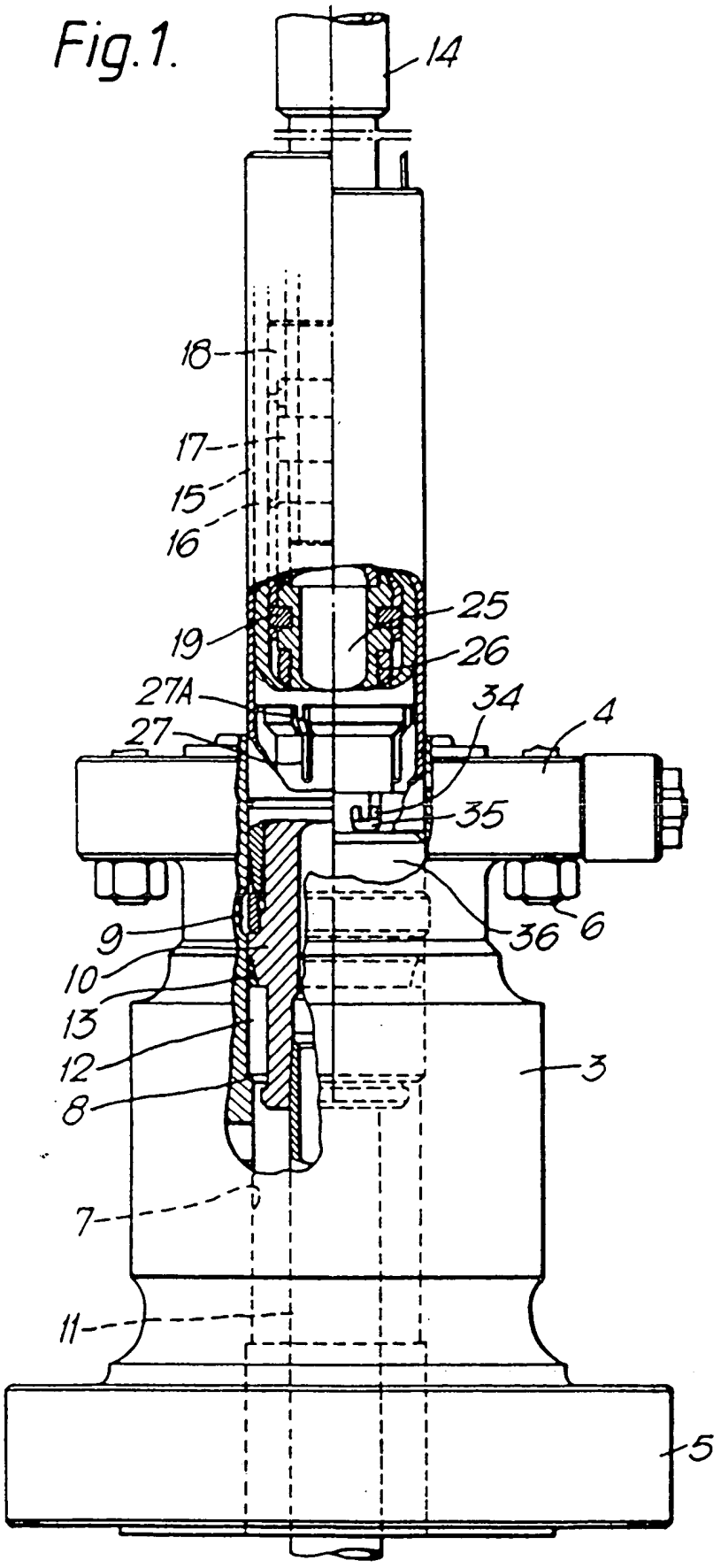
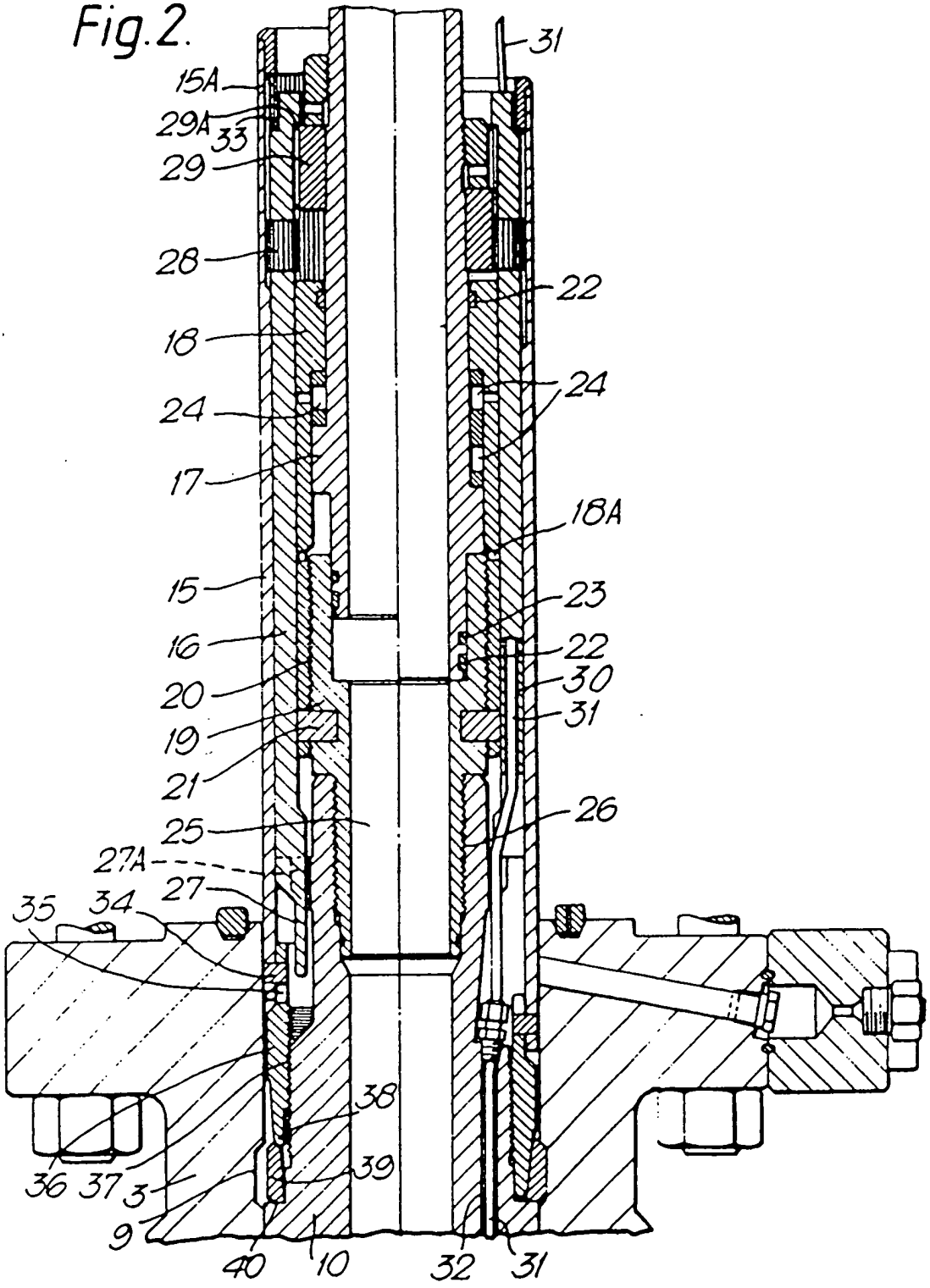


Fig.2.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EUROPEAN SEARCH REPORT

Application Number

EP 91 30 9001

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 343 298 (CAMERON) * column 3, line 29 - column 5, line 10; figure 1 *	1,3,9	E21B3/04
A	US-A-3 972 546 (PUTCH) * column 1, line 40 - line 56; figures 1-13 *	1,3,9	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			E21B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18 JUNE 1992	FONSECA Y FERNANDEZ

CATEGORY OF CITED DOCUMENTS

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